

SANDSTONES AND CONGLOMERATES IN OHIO

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INTRODUCTION

The pioneer settlers, mainly through necessity, first turned the local sandstones in the eastern half of Ohio to profitable account in the construction of homes, mills, factories, dams, bridges, canal locks, furnaces, cupolas, public buildings, etc. Such rocks were widely distributed over that area, had outcrop exposures favorable for quarrying, were readily fashioned by the mason into desired forms and, in general, were pleasing to the eye or appealed to the sense of durability. The first homes were built of logs but in these the chimneys most commonly were constructed of sandstones laid in mud. For example at Schoenbrun, established by the Moravians in 1792 and burned soon after by the whites, the locations of the old buildings were established by the hearthstones and the corner foundations hid during the lapse of time. The dams of early mills, built from 1790 on, used rock of some kind for the entire structure, for the shore anchors or for weighting the timbers if made of wood. Piles of moldering sandstones still mark the sites of Hopewell furnace built in 1804, Montgomery in 1806, Rebecca in 1807, Licking in 1808, etc. The remaining evidence for the first paper mill west of the Allegheny Mountains, and built on the Little Beaver Creek in 1805, is remnants of the stone abutments on the shores and a row of holes in the rocks forming the floor of the stream. Such instances may be duplicated many, many times and with a wide variety of older works.

DEFINITION OF TERMS

Sandstone may be defined as a rock of sedimentary origin derived by consolidation of sand through compaction and cementation by bonding components. The sand grains may be nearly pure quartz or quartz with feldspar, mica, zircon, rutile, garnet and other minerals. In size the grains may vary from fine to coarse but in any given rock they are usually rather well sorted. The common bonding components are iron oxides in some form, silica, either amorphous or crystalline, and carbonates of calcium and magnesium. Others less abundant but common are phosphates, organic matter and manganese oxide.

Conglomerate is a consolidated water-lain rock made up partially or nearly wholly of pebbles, usually rounded, embedded in a matrix of finer material, generally sand. The pebbles may be derived from most any kind of hard rock but those from quartz or quartzite are the most common. Usually the conglomerate rock is a massive stratum varying both vertically and laterally from a sandstone with few pebbles to one made up largely of the coarse material, the sand filling only interstitial space. Cross-bedding and lenticularity are conspicuous features of most conglomerates when viewed in mass.

GENERAL OCCURRENCE

In Ohio sandstones and conglomerates occur at various horizons throughout the entire rock column of some 6,800 feet from the basement pre-Cambrian crystallines to the upper-most strata of the Permian system. However, the quantity of such strata varies greatly in the different systems being abundant in some and nearly absent in others. On account of so much variation and so many wants with the sandstones and conglomerates a true estimate is hardly possible. However, the data given below are relatively accurate.

System	Total Thickness of Rocks, Feet	Total Thickness of Sandstone and Conglomerate, Feet
Permian.....	626	147
Pennsylvanian.....	1,115	355
Mississippian.....	675	375
Devonian.....	770	5 ?
Silurian.....	800	20
Ordovician.....	2,095	0 ?
Cambrian.....	720	360
	6,801	1,105

Thus an abundance of siliceous strata is present in the Mississippian, Pennsylvanian, Permian and Cambrian systems whereas an impoverishment of such materials prevails in the Ordovician, Devonian and Silurian systems, the latter three being made up of dolomites and limestones with minor quantities of shale.

CAMBRIAN SYSTEM

In the Vance¹ and some ten other wells in the western half of Ohio that have penetrated the strata from the base of the great Trenton-Black River group to the crystalline gneisses and schists many sandstone lenses, some quite thick, are inter-

¹See "Paleozoic and pre-Cambrian Rocks of the Vance Well, Delaware County, Ohio," by Wilber Stout and Carl A. Lamey, *The Bulletin of The American Association of Petroleum Geologists*, Vol. 24, No. 4, April, 1940, page 687.

spersed in dolomite in the basal 720 feet or more of the section. Here, the sandstones, either pure or dolomite bonded, make up more than half of the deposits. In the Vance and also in a few of the other wells with detailed sections, the sandstone most conspicuous lies directly above the crystalline rocks, is exceptionally pure and measures 125 feet or more in thickness. These sandstones provide excellent reservoirs for the accumulation of petroleum, natural gas and brine but so far they have yielded only the latter. The brine² is highly concentrated and is of value for the chemical industries. In the Vance well it was found at a depth of 3,820-3,825 feet.

ORDOVICIAN SYSTEM

The rocks of the Ordovician system, some 2,095 feet in thickness, are nearly entirely dolomites, limestones and calcareous shales. The only well known and definitely correlated sandstone in the system is the St. Peter lying at the base of the Black River formation. However, this member is largely wanting and when present thin and impure. The horizon yields a weak brine and the green shale and dolomite, 10 to 15 feet above the disconformity, have furnished in scattered wells small quantities of petroleum and natural gas.

SILURIAN SYSTEM

Throughout this great system of rocks, about 800 feet in thickness, the dominating deposits are dolomites, calcareous shales and limestones, many of which are of great interest industrially. The only sandstone of any importance is the Clinton of the driller which is of Medina age and correlative with the Whirlpool sandstone of the Niagara Gorge (New York) section.

CLINTON SANDSTONE

The Clinton sandstone of the driller in Ohio is of Medina age and is correlative with the Whirlpool sandstone of the Niagara Gorge (New York) section. Its position is directly above the Elkhorn or Queenstown or "Red Medina" shale and from 100 to 250 feet below the base of the well known Niagara dolomites. This formation enters Ohio from the east or northeast, thins rapidly westward and becomes absent or very indefinite in the east central part. Its western boundary is marked roughly by a line from Lorain on Lake Erie through Mansfield, Mount Vernon, Lancaster, Laurelville and Jackson to Ironton on the Ohio River. It is not known on the outcrop in southwestern Ohio. The Clinton sandstone varies from 1 to 100 feet or more in thickness, is always fine in texture and in the eastern part of the state is cemented to a hard quartzitic rock. However this sandstone is the reservoir for the great natural gas and petroleum fields stretching nearly continuously from Cuyahoga and Lorain counties on the north to Lawrence County on the south. Throughout the field, opened near Lancaster in 1887 and still active, over 26,000 wells have been drilled yielding immense volumes of natural gas and large supplies of petroleum. It has proved one of the most valuable formations in Ohio.³

DEVONIAN SYSTEM

The rocks of the Devonian system in Ohio are all of marine origin, average between 700 and 800 feet in thickness and include, in order of abundance, shale, limestone, dolomite and sandstone, the latter forming a very minor part of the

²*Ibid.* Pages 673-4.

³For reference see: Geol. Sur. Ohio, Vol. VI, pages 12, 75, 354 and 783; Geol. Surv. Ohio, Bull. 1, "The Occurrence and Exploitation of Petroleum and Natural Gas in Ohio," pages 20, 101, 120; Geol. Sur. Ohio, Bull. 12, "The Bremen Oil Field," pages 16, 17, 22, 23, 24, 38, 65; also Bulletins 20, 21, 24, 28, 31, 35, 37.

whole. The siliceous strata comprise the Oriskany sandstone at the base of the system and the Marcellus, Olentangy and Ohio shales in the middle and upper portions.

ORISKANY SANDSTONE

The type locality for the Oriskany sandstone is Oriskany Falls, Oneida County, New York. The formation extends westward from New York through Pennsylvania into eastern Ohio, becomes absent in the central part of the State but appears again in the northwestern portion. In the latter area it is known as the Sylvania sandstone. The formation is erratic in thickness varying from 1 to 100 feet but ranging usually between 10 and 40 feet. Its chief economic value is for the production of natural gas and petroleum, the chief fields being in Ashtabula, Tuscarawas, Guernsey, Coshocton and Muskingum Counties. Formerly the Sylvania sandstone of northwest Ohio was used in glass making and was ground to a fine powder for potters flint, paint pigment and foundry uses.⁴

MISSISSIPPIAN SYSTEM

Aside from the Maxville limestone placed at the top of the section but absent over much of the area the rocks of the Mississippian system are entirely siliceous in character, that is, they are sandstones or siliceous shales. The total thickness of these strata varies from place to place but on the average approximates 675 feet. The deposits are wholly marine in origin and show much evidence of shallow water deposition. The system outcrops in a wide belt extending northward from Scioto County on the Ohio River to Lorain and Medina Counties thence eastward to Trumbull County on the Ohio-Pennsylvania line. The shales are employed extensively for ceramic products and the sandstones have proved useful for building stone, abrasives, oil and gas, brines, fire stone, glass sand and molding sand.

EUCLID SANDSTONE

Although the Bedford formation primarily is shale yet in some areas it bears thin to medium bedded layers of sandstone either closely or widely spaced in the shale. In the Cleveland district this sandstone has long been quarried under the name of "Euclid bluestone," is dense and fine grained and weather resistant. The deposits range from 15 to 30 feet in thickness and the individual layers from 2 inches to 3 feet 6 inches. It finds employment for flagging, foundations, cellars and when sawed for caps, sills and steps.⁵

BEREA SANDSTONE

The Berea sandstone of Mississippian age, and named by Newberry in 1870, is one of the best known rocks of this class in Ohio. It is important along the outcrop as a source of building stones and abrasives and under deep covering as a storage reservoir for petroleum, natural gas and salt brines. The formation expands 5 to 225 feet in thickness but averages about 45 feet. The typical stone is massive in structure, medium fine in grain size, rather open in texture and light gray to slight buff in color. It quarries with good economy and works well either by chipping or sawing. The outcrop of the Berea sandstone is marked in a general way by small or large quarries in Trumbull, Ashtabula, Geauga, Lake, Cuyahoga, Lorain, Erie, Huron, Crawford, Morrow, Delaware, Franklin, Pickaway, Ross, Pike, Scioto and Adams Counties. The most prominent quarries are confined to

⁴For reference see: American Association of Petroleum Geologists, "Natural Gas in Central and Eastern Ohio," June, 1935, page 907.

⁵For detail see: "Geology and Mineral Resources of the Cleveland District," U. S. Geol. Sur. Bull. 818, pages 107-111; "The Devonian and Mississippian Formations of Northeastern Ohio," Geol. Sur. Ohio, Bull. 15, page 51; "Building Stones of Ohio," Geol. Sur. Ohio, Bull. 18, pages 69-70.

northern Ohio in Lorain, Cuyahoga and Erie Counties. The uses of the Berea sandstone are many, principal among them are building stone, curbing, flagging and riprap. It is the chief source in the United States for grindstones, whetstones and related rubbing stones. Formerly it was used for mill stones for grinding barley and other grains. Of recent years a new and important use is sawed stone for refractory linings of cupolas, in replacement of silica brick. Such blocks are cheap, stand up well against heat and slag and are easily replaced.

The Berea sandstone ranks third in the production of petroleum and natural gas, being surpassed only by the Trenton and the Clinton. From the Berea the yield has been largely oil. The depth of the wells varies from 100 to 2,000 feet or more. On the average the wells are not large producers but are long lived. The largest pools are in Athens, Washington, Perry, Morgan, Muskingum, Noble, Monroe, Belmont, Harrison, Jefferson, Carroll, Columbiana and Mahoning Counties. Some production is also obtained in Gallia, Meigs, Vinton, Hocking, Guernsey, Coshocton, Tuscarawas, Holmes and Stark Counties. This formation is a consistent producer of brine except where structural relief is such as to impede its migration. The flow of brine, however, is not large nor is the concentration especially strong, the yield of salts in the brine varies greatly but commonly ranges from 50 to 150 grams per liter. Formerly brine from the Berea sandstone was utilized for salt making near Dover in Tuscarawas County and at Lisbon and Salineville in Columbiana County.⁶

BUENA VISTA SANDSTONES

The Buena Vista formation is recognized as such from the Ohio River in Adams County northward to near Mansfield in Richland County, beyond which it breaks up and becomes more indefinite. It is made up of a great series of sandstone and shale layers occupying from 100 to 150 feet of the lower part of the Cuyahoga formation. Such deposits are best developed in western Scioto, eastern Adams and western Pike Counties. The sandstone beds vary from one inch to six feet in thickness, but the majority are under 16 inches. Further, they maintain remarkable regularity in their lateral extension. These sandstones are fine in texture, break well in any direction, are bluish gray to rich brown in color and are firmly cemented with clay matter and iron oxides. At present the active quarrying is largely confined to McDermott in Scioto County. Formerly, however, the deposits were worked in a large way at Buena Vista, Rarden, Henly, and Carey Run in Scioto County, Piketon and Waverly in Pike County, at Lithopolis in Fairfield County, and Blacklick in Franklin County. In southern Ohio the output consists of sawed stone for building, grave vault, flagging, curbing purposes and perch stone for bridges, abutments, retaining walls and foundations.

The Buena Vista sandstones also produce petroleum and natural gas, especially the latter, under the driller's term of Hamden sand of Jackson and Vinton Counties, Weir of West Virginia and Welsh Stray of Monroe County. In Ohio the outstanding gas pool is near Hamden in Vinton and Jackson Counties.⁷

BLACK HAND SANDSTONE

The Black Hand formation forms conspicuous deposits along the outcrop in central Ohio from southwestern Hocking County through Fairfield, Licking and Knox Counties to north of Mansfield in Richland County. Further it extends

⁶References: Geol. Sur. Ohio, Bull. 18, "Building Stones of Ohio," pages 72-118; Geol. Sur. Ohio, Bull. 1, "The Occurrence and Exploitation of Petroleum and Natural Gas in Ohio," many references; The American Association of Petroleum Geologists, June, 1935, pages 904-5; Geol. Sur. Ohio, Bull. 37, pages 14-16, 52-63.

⁷Geol. Sur. Ohio, Bull. 18, "Building Stones," pages 108, 122-129; Bull. 23, "Geology of Camp Sherman Quadrangle," pages 104, 113, 156.

on southeastward under deep covering into West Virginia as shown by the drill. It is a massive deposit, often one great ledge with few if any distinct stratification planes. It varies in thickness from 50 to 200 feet or more. The stone changes in texture from a coarse-grained sandstone to a rather pebbly conglomerate. Commonly, however, it is a sandstone with pebbles scattered through the mass or concentrated to local lenticular layers. The stone is generally highly cross-bedded, the planes being confined to definite lenticular boundaries which are rather closely spaced. Outstanding features are thus cross-bedding and lenticularity. The usual cementing medium is iron oxides. This sandstone is commonly of a decided buff color but locally this changes to light, light gray, pink, reddish and brown.

This sandstone has been used since pioneer days but in a rather desultory way for building stone and heavy masonry. It has been quarried for such purposes near Mansfield in Richland County, along the Licking River at Hanover and Toboso in Licking County, along the Hocking River at Lancaster and Sugar Grove in Fairfield County and at Rockbridge and Logan in Hocking County. Through crushing followed by screening, air separation or washing, the Black Hand sandstone finds employment on the markets for molding sand, mortar sand, sand finish of plastering, sand blasting, engine sand and glass sand. The largest active plant (1943) is at Millwood in Knox County, preparing glass sand by acid treatment and washing.

To the driller the Black Hand sandstone is known as the Big Injun sand. When detached from the main body the lower portion is called the Squaw sand. These sandstones produce both petroleum and natural gas, but largely the latter. The Big Injun sand is of most importance in Washington and Monroe Counties and of less worth in Athens, Vinton, Morgan, Muskingum, Noble, Guernsey and Belmont Counties.

In the Pomeroy district of Meigs County the Black Hand sandstone is one of the important sources of brine for the salt industry. Formerly such brines were used extensively along the Hocking River and along Sunday Creek in northern Athens County and along the Muskingum River in southern Muskingum and northern Morgan counties. This formation yields a large flow of concentrated brine which is high in bromine and practically free from sulphates.

The Black Hand sandstone is of value also for the picturesque and attractive scenery presented along the outcrop. The deeply entrenched gorges, box caverns, falls and cascades and bold cliffs yield recreation places and camp sites of value for scenery, wild life and pleasure. Ash Cave, Cedar Falls, Old Man's Cave, Conkle Hollow, Rock House, Cantwell Cliffs, Clear Fork, Jacob's Ladder, Christmas Rock, Mt. Pleasant, Licking Narrows, Rain Rock and Kokosing gorge are some of the outstanding spots that may be mentioned.⁸

BYER SANDSTONE

The Byer sandstone belongs near the base of the Logan series of the Mississippian system. This formation at the type locality, Byer in northern Jackson County, is a fine grained, even bedded sandstone of a yellowish or buff color. The bonding components, consisting of clay matter and iron oxides, are rather high, but the stone is only locally weather resistant. In many areas more or less of the sandstone is replaced by gray siliceous shale. The thickness of the Byer formation is about 60 feet in Scioto County, 70 feet in Vinton, 100 feet in Ross and 70 feet in Wayne. Economically it is of small worth, supplying only small quantities of building stone for local needs.⁹

⁸For reference see: Geol. Sur. Ohio, Bull. 37, "Brines of Ohio," pages 22, 23, 47-52; Bull. 18, "Building Stones," pages 140-142; American Journal of Science and Arts, 3rd series, Vol. XVI, 1878, pages 216-217.

⁹For references see: Geol. Sur. of Ohio, Bull. 23, page 154; Bull. 31, pages 52-53.

ALLENSVILLE CONGLOMERATE

The Allensville conglomerate, named by Hyde for the village of Allensville in western Vinton County, is the third unit in the Logan series of the Mississippian system. It is quite distinctive in that it is a fine but very even-grained conglomerate, in size about like wheat grains. It may occur in one or in two distinct beds in sandstone and siliceous shale of the ordinary Waverly types. In thickness the conglomerate zones vary from one inch to four feet and that of the entire member from 2 to 25 feet. The Allensville formation is recognized along the outcrop from Scioto to Summit County. If present in larger quantities the well sorted Allensville conglomerate would be useful for several purposes.¹⁰

VINTON SANDSTONE

The youngest deposits in the Waverly group of rocks of Mississippian age are those of the Vinton formation which was named by Hyde for exposures in the western part of Vinton County. In this area it is made up of a series of sandstones and shales, but elsewhere it may vary from massive sandstones with little or no shale to shales with only thin lenses of sandstone. The sandstones, commonly, are fine grained, thin to massive bedded and gray to drab in color. The thickness of the formation varies from 5 to 180 feet, depending on the amount left by the erosion cycle at the close of Mississippian time. Under deep covering in eastern Ohio the Vinton sandstone becomes the Keener sand of the driller and is very important as a source of petroleum and natural gas in Jefferson, Belmont, Monroe, Harrison, Washington, Noble and Morgan counties. It also contains brine but so far this has not been utilized for commercial purposes.

PENNSYLVANIAN SYSTEM

The great group of rocks now placed in the Pennsylvanian system was first defined, in 1838, in Pennsylvania, by Henry D. Rogers in work done for the United States Government. It has been and is of enormous importance in the Appalachian field for its coals, clays, shales, sandstones, limestones, iron ore, petroleum, natural gas and brines. Throughout this field Pennsylvanian rocks cover an area of more than 70,800 square miles in central and western Pennsylvania, eastern Ohio, western Maryland, western Virginia, West Virginia, eastern Kentucky, eastern Tennessee and northern Alabama. In Ohio such strata are found over an area of approximately 12,340 square miles. The Pennsylvanian system is sub-divided into four series, Pottsville, Allegheny, Conemaugh and Monongahela.

POTTSVILLE SERIES

The Pottsville is the basal series of the Pennsylvanian system and is of vast importance for its mineral resources. The total area of such rocks appearing at the surface in Ohio is not far from 3,760 square miles. It extends over parts or all of Trumbull, Mahoning, Geauga, Cuyahoga, Medina, Summit, Portage, Wayne, Stark, Holmes, Tuscarawas, Knox, Coshocton, Licking, Muskingum, Perry, Fairfield, Hocking, Vinton, Pike, Jackson, Scioto and Lawrence Counties. This formation averages about 255 feet in thickness but varies, on account of disconformities, between 175 and 400 feet. The Pottsville series comprises all the strata from the Mississippian rocks to the base of the Brookville coal. The recognized and named strata include 12 coal beds, 13 clays, 7 iron ores, 12 sandstones, 1 conglomerate and numerous shales. Here only the Sharon conglomerate and the Massillon and Homewood sandstones need be considered as of more than ordinary interest.

¹⁰See references: Geol. Sur. Ohio, Bull. 23, page 154; Bull. 31, pages 53-55.

SHARON CONGLOMERATE

The Sharon conglomerate at the base of the Pottsville series is one of the outstanding deposits of Ohio. It is of interest for its geological history, for its physiographic and scenic features, for the many uses to which it is applied and for its storage and yield of petroleum, natural gas, salt brine and rock water. The stone varies in composition from a medium-grained sandstone to a coarse pebbly conglomerate, very loosely cemented. The deposits always occupy broad, deep depressions, resembling erosion valleys, cut in the older Mississippian floor. The deposits are very erratic in distribution and vary from 10 to 250 feet in thickness. The pebbles are vein quartz with a high purity. They were derived from the Canadian granite and gneiss fields to the north and after passing through long cycles of weathering and transportation came to rest in great beds in Ohio and in areas in adjacent states. In southern Ohio the main fields are in eastern Scioto, eastern Pike and western Jackson Counties and in the northern part of the State in eastern Wayne, Stark, Mahoning, southern Trumbull, Portage, Summit, eastern Medina, southeastern Cuyahoga and Geauga Counties.

The Sharon conglomerate is the Maxton sand of the driller and in southeastern Ohio yields petroleum and natural gas, also brine of fair strength. Where present in good development along the outcrop it is an excellent source for rock water and for springs, some unusual. It provides also much scenic beauty in both southern and northern Ohio such as Rock Run, White's Gulch, Canter's Cave, Big Rock, Nelson Ledges, Thompson Ledges, Boston Ledges, Cuyahoga Falls and Little Mountain. The Sharon conglomerate is of economic importance for the manufacture of silica brick, for reduction to the metal silicon, for pebble aggregate for nitrating plants, for paper, stucco work and sand blasting. Some glass and foundry sand are produced from selected material. Locally it is used for road facing, concrete work and railroad ballast.

MASSILLON SANDSTONE

The Massillon sandstone extends with some wants across the State from Youngstown in Mahoning County to the Ohio River in eastern Scioto County. It forms prominent exposures in Scioto, Jackson, Vinton, Hocking, Perry, Muskingum, Coshocton, Holmes, Wayne, Stark and Mahoning Counties. Stratigraphically the position of the Massillon sandstone is in the lower part of the Pottsville series, not far above the Quakertown coal. The thickness of the formation varies from 5 to 60 feet but the general measurement is between 20 and 45 feet. This member is usually massive in character, being broken by few bedding planes of sharp definition. Commonly it is conspicuously cross bedded, indicating its origin in shallow water with movement as along seashores. In texture it varies from a fine grained sandstone to one quite coarse or pebbly. The stone normally is light gray in color but through weathering it attains shades of drab, pink, brown and even variegated. Locally the Massillon sandstone is used in a large way for building stone for both light and heavy masonry. It is suitable also for glass sand, core sand, abrasives, etc. Under shallow covering it yields excellent supplies of water both for farm and home consumption and for industrial purposes. The Massillon correlates with the First Salt Sand of the driller and under deep covering in southeastern Ohio yields petroleum, natural gas and brine.

HOMEWOOD SANDSTONE

The Homewood sandstone is erratically developed along the line of outcrop across the state from Mahoning County on the east to Scioto and Lawrence Counties on the south. Its stratigraphic position is best defined as lying between the Upper Mercer and the Putnam Hill limestones, not uncommonly filling most of the interval. The thickness of the member varies from 5 to 60 feet. Where well

developed this sandstone occurs in massive ledges broken by irregular and widely spaced bedding planes and by vertical joints. It is somewhat cross-bedded, but shows little tendency to part, on weathering, along these planes. The Homewood is commonly a fine-textured sandstone. It is composed in the main of well rounded quartz grains admixed with a noticeable quantity of mica flakes. The bonding components are iron oxides and clay matter. The normal color of the stone is rather pleasing, ranging from light gray to soft drab shales. In Ohio the Homewood sandstone has been worked most largely around Zanesville where it was employed for years for foundations, retaining walls, culverts, steps, walks and house trimmings.

ALLEGHENY SERIES

The Allegheny series in Ohio is of special importance for its great clay beds and for its thick and persistent coals and is of some value for its iron ores, shales, sandstones and limestones. This series of rocks begins at the base of the Brookville coal and includes all the strata to the top of the Upper Freeport coal. The thickness of this section varies from 175 to 250 feet, but averages about 200 feet. The area of these rocks exposed at the outcrop is not far from 2,600 square miles. Sandstones, part shaly or fine in texture, constitute about 40 per cent of the total strata. In a general way the Allegheny series extends in a broad belt from Lawrence County on the Ohio River northward and eastward across Jackson, Vinton, Hocking, Perry, Athens, Muskingum, Coshocton, Tuscarawas, Stark and Jefferson Counties to Columbiana County on the Ohio-Pennsylvania state line. Small areas are also present in some of the adjoining counties. It contains a few sandstones of regional continuity which are of interest for their economic value. These are Clarion or Hecla, Lower Freeport and Upper Freeport.

CLARION OR HECLA SANDSTONE

In Ohio the Clarion is one of the most prominent and persistent sandstones in the coal formations. It extends with some rather local wants from Columbiana County to Lawrence County. Where present such deposits take up most of the interval between the Putnam Hill limestone and the Clarion coal. The usual range in thickness is between 20 and 55 feet. The stone is massive in character, is somewhat marked by cross-bedding planes and varies from medium fine to coarse in texture. The color range is from nearly white to drab. The common cements are iron oxides and clay matter, the latter often predominating. Only locally, however, are the bonding components sufficiently strong and weather resistant for the stone to be satisfactory for building purposes. The Clarion sandstone has had a long and varied use. Formerly in Lawrence, Scioto, Jackson, Gallia, Vinton and Hocking Counties it was employed for building the stacks, linings and bridge walls of charcoal furnaces and for linings of ore kilns. In the Zanesville district the Clarion sandstone was used in the construction of some of the finest homes, for building canal locks, for foundations and for decorative work with brick masonry. Further, it supplies stone for various building purposes in Coshocton, Holmes and Tuscarawas Counties.

LOWER FREEPORT SANDSTONE

The Lower Freeport is far above the average coal formation sandstone in the continuity of the stratum across the state. It outcrops prominently in Columbiana, Carroll, Tuscarawas, Coshocton, Muskingum, Perry, Athens, Vinton, Jackson, Gallia and Lawrence Counties. Stratigraphically it is placed in the interval between the great Middle Kittanning coal and the Lower Freeport limestone. The deposits vary from 5 to 75 feet or more in thickness. The Lower Freeport sandstone is usually massive in character, more or less marked by cross-bedding planes, somewhat micaceous in mineral content and medium coarse but uniform

in texture. The freshly quarried stone varies in color from very light gray, through yellowish and drab to reddish brown, the shades depending largely on the state of oxidation of the iron components. The chief bonding material is iron oxide in the limonite form. In Ohio the Lower Freeport sandstone was employed, as early as 1805, for building purposes by the pioneers of Columbiana County. At various places along the line of outcrop across the state it has served many purposes such as construction of houses, blast furnaces, mills and mill dams, carding mills, retaining walls, culverts, bridges, abutments and foundations.

UPPER FREEPORT SANDSTONE

The Upper Freeport sandstone belongs in the interval between the Lower Freeport coal and the Bolivar clay. It may be absent from the section, may fill only a part of the interval, may occupy all of this space or may expand so that it replaces overlying or underlying beds. It is usually a loosely bonded, medium-grained sandstone, decidedly micaceous and somewhat ferruginous in character. Clay matter also forms part of the bond. It is always cross-bedded, the planes being best marked on weathered surfaces. The color of the rock varies from light gray to brownish buff, the intensity of the shade depending on the quantity of the iron components present and on the degree of weathering. This stratum varies in thickness from 1 to 60 feet. The Upper Freeport sandstone is locally developed from the Ohio River in Lawrence County, across western Gallia, eastern Vinton, western Athens, eastern Perry, central Muskingum, northwestern Guernsey, southeastern Tuscarawas, northwestern Carroll and central Columbiana County to the Ohio-Pennsylvania state line. This formation has been utilized for common building purposes in local areas, for pulpstones in Jefferson County and for molding sand in Muskingum and Perry Counties.

CONEMAUGH SERIES

The third division of the Pennsylvanian system is the Conemaugh series which embraces all the rocks between the top of Upper Freeport coal and the base of the Pittsburgh coal and which includes shales, limestones, sandstones, coals, clays, and nodular iron ores. The thickness of this rock section varies from 340 to 500 feet but the average measurement is close to 400 feet. Conemaugh rocks are exposed in the southeastern part of the State in a broad belt varying from 10 to 20 miles in width and extending from the Ohio River in Lawrence County to the Ohio-Pennsylvania line in Columbiana County. The total area of such rocks exposed at the surface in Ohio is not far from 3,000 square miles. Some marine strata are present in the lower half of the series, the Ames limestone or the Skelley limestone being the highest known formations laid down in the sea. Above this horizon the strata are all of fresh water origin or are thus land laid deposits. Fresh water deposits are also present in the lower half of the Conemaugh series or below the Ames limestone. Sandstones form a prominent part of the entire sections. These are usually massive in character and locally well bonded by cementing compounds. The most prominent formations are the Lower Mahoning, Buffalo, Cow Run and Morgantown sandstones.

LOWER MAHONING SANDSTONE

The Lower Mahoning or as usually identified the "Mahoning" sandstone is found in the interval between the Upper Freeport coal and the Mahoning coal. Usually where present it takes most of this interval but locally so thickens that it replaces the underlying or the overlying coal. The thickness of the formation varies from 5 to 50 feet, but the usual measurement falls between 15 and 35 feet. Texturally it changes from a fine-grained to a coarse-grained or even to a conglomeratic sandstone. The pebbles, which are of milky quartz and commonly not more than one-fourth inch in diameter, are for the most part confined to the

basal portion of the deposits. The Mahoning sandstone is commonly cross-bedded. In places this physical feature is prominently developed. Great variation is also shown in the hardness and in the weather resistance of the material. In general it is poorly cemented and crumbles readily on exposure to the elements. The coarse-grained rock is often more firmly bonded, as shown by resistant blocks strewn along the outcrop and by conspicuous ledges projecting from the hillsides. This sandstone is locally well developed in Columbiana, Carroll, Harrison, Guernsey, Muskingum and Lawrence Counties. It has been quarried for the trade in Harrison County and utilized locally in other places.

BUFFALO SANDSTONE

The Buffalo sandstone is placed a few feet below the Cambridge limestone and not far above the Brush Creek limestone or fossiliferous block shale. The deposits are local in distribution, being best developed along Stillwater Creek in Tuscarawas County, near Sherrodsville in Carroll County and along Leading Creek in Meigs County. The thickness of the member not often exceeds 30 feet. Where well developed the stone is massive in character, coarse to pebbly in texture and gray to buff in color. It weathers well, becoming darker through exposure. The Buffalo sandstone has been quarried in a large way at a few places for stone for houses, churches, schools and heavy masonry. Under deep covering it becomes the Buell Run sand of the driller and yields petroleum, natural gas and brine.

COW RUN SANDSTONE

The Cow Run sandstone is of local development in Ohio. It is well represented by exposures along the Muskingum River in Muskingum and Morgan Counties. Stratigraphically the member lies on or only a few feet above the Anderson coal and on the average about 45 feet below the Ames limestone. The thickness of the member varies from 5 to 40 feet, but averages about 20 feet. It is coarse grained, loosely cemented, light gray to drab in color and without definite partings or bedding planes. Along the Muskingum River in southern Muskingum and northern Morgan Counties the Cow Run sandstone was quarried in a large way for shipment and for local use. The chief purposes for which it was utilized were canal locks, bridge piers, abutments, culverts, dams, foundations and retaining walls. To a less extent it was employed for steps, caps, sills, chimneys, fireplaces, cellars and spring houses. The Cow Run is also one of the great sands of the oil driller and very important in Morgan, Washington, Noble and Athens Counties.

MORGANTOWN SANDSTONE

The Morgantown sandstone is well described by Condit:¹¹ "Like all the sandstones of the Conemaugh, this bed is very irregular in its occurrence, being conspicuous in one place and entirely wanting a short distance away. The rock varies from a fine-grained, bluish gray freestone, similar to the Berea at Cleveland, to a coarse-grained, massive, yellowish gray bed 30 feet or more in thickness. Where present in massive form, the Morgantown sandstone is seldom separated from the underlying Ames fossiliferous limestone by more than 25 feet of shale, and often the interval is only 10 to 15 feet. This stratum is found over much of the eastern part of Ohio, where geologically due, and varies in thickness from 15 to 30 feet. The greatest thickness in eastern Ohio is probably in southeastern Carroll County and in the adjacent parts of Harrison. It is also well developed locally in Muskingum, Morgan, Athens, Meigs and Gallia Counties." It provides many farms and villages along and near its outcrop with a satisfactory water supply and is the Wolf Creek sand of the oil driller.

¹¹Geol. Survey of Ohio, Bull. 17, pages 25-26.

MONONGAHELA SERIES

The Monongahela series in Ohio is confined to a belt varying from 5 to 40 miles in width and bordering the Ohio River or not far back from this stream from northern Jefferson County to southern Lawrence County. Rocks belonging to this series are found in eastern Lawrence, eastern Gallia, Meigs, eastern Athens, Washington, Morgan, southeastern Muskingum, Noble, Monroe, southern Guernsey, Belmont, eastern Harrison and Jefferson Counties. The area of outcrop is about 1,213 square miles and the total area in Ohio, with the overlying Permian, is approximately 2,980 square miles. The general thickness of the series varies from 235 to 263 feet but averages 248 feet. This section begins at the base of the Pittsburgh coal and ends at the top of the Waynesburg coal. It is made up mainly of shales, fresh-water limestones and sandstones, but it also contains coals, clays and nodular iron ores. Few of the sandstones are persistent over wide areas, the chief ones are Lower Sewickley, Upper Sewickley and Uniontown. In general these sandstones lack purity and are not weather-resistant, hence they have been of little economic value. The most important is the Upper Sewickley.

UPPER SEWICKLEY SANDSTONE

The Upper Sewickley sandstone is present only in local areas along the western and southern margins of the Monongahela field of rocks in Ohio. This member is best represented in eastern Noble, north central Washington, southeastern Muskingum and southern Meigs counties. Such deposits usually expand or contract erratically and suddenly between the limits of 1 and 70 feet. The Upper Sewickley sandstone is not distinctive in texture, in structure or in composition from other sandstone in the upper part of the Pennsylvanian system. Only locally is it sufficiently well bonded for building stone and heavy masonry. It has been utilized to a small extent near Pomeroy in Meigs County and along Duck Creek in Noble and Washington Counties. It is the Goose Run sand of the oil driller, locally providing small fields. Where present along the outcrop it performs a service for a water supply to farms and villages.

PERMIAN SYSTEM

DUNKARD SERIES

The Dunkard series of rocks in Ohio is confined to a narrow belt bordering the Ohio River and extending from southern Jefferson County across Belmont, Monroe, Washington and Athens Counties to southern Meigs County. Small outlying tracts are also present in southern Noble and eastern Morgan Counties. The total area is not far from 1,767 square miles. The maximum thickness of this series of rocks in Ohio is approximately 626 feet. It includes sandstones, shales, limestones in quantity and clays and coals in thin beds. The sandstones recognized geologically are, in ascending order, Waynesburg, Mannington, Lower Marietta, Upper Marietta, Hundred, Jollytown, Fish Creek, Nineveh and Gilmore. These make up nearly 45 per cent of the total section. Such sandstones have been used in a large way for the grindstone and pulpstone industry in the Marietta district. Of these the ones of most importance are the Upper Marietta and the Hundred.

UPPER MARIETTA SANDSTONE

This sandstone came into prominence for its use in the manufacture of grindstones and pulpstones. It is described by Stauffer and Schroyer as follows:¹² "This is an exceedingly massive sandstone showing rather indistinct lamination which occasionally is very pronounced. It is a medium grained sandstone which at places becomes very coarse. On fresh exposures the color is gray, but it weathers

¹²Geol. Sur. of Ohio, Fourth Series, Bull. 22, page 20.

to a buff or even a brownish color. This is the chief grindstone horizon of the Marietta region and the rock was named by I. C. White from the outcrop and numerous quarries in it in the vicinity of that city."

HUNDRED SANDSTONE

The Hundred is one of the conspicuous sandstones in the Washington formation of the Dunkard series. Its area of outcrop is small and is largely confined to the deep Parkersburg-Lorain syncline in the western part of Washington County. The description given by Stauffer and Schroyer follows:¹³ "The Hundred sandstone as it occurs in Ohio is a coarse massive rock made up of sharp quartz grains rather well cemented with lime. The lower half of the deposit is likely to contain quartz pebbles, and sometimes they are abundant and rather large. Ripple marks are common and the mud covered surfaces of some layers show well developed sun cracks. Light-colored mica, probably muscovite, is distributed throughout, but the dark micas are rare. Hard brown masses of boulder-like shape occur in the upper part of this sandstone in the vicinity of Marietta and have probably been formed by the deposition of an excess of iron which in such spots acts as the chief cement. It is one of the sandstones used in the manufacture of grindstones in Ohio where its horizon is 140 feet below the Nineveh limestone."

USES OF SANDSTONES, CONGLOMERATES AND SANDS

Sandstone for abrasive purposes:

- Grindstones.
- Pulpstones for grinding paper pulp.
- Wheels for grinding tan bark (pioneer days).
- Whetstones.
- Rubbing stones.
- Buhr-stones (Peninsula Quarry, pioneer days).
- Millstones, chasers and dragstones.
- Stones for grinding paint pigments (pioneer days).

Sand for abrasive uses:

- Sandpaper and sand belts.
- Sand blasting.
- Scouring powers and pastes.
- Buffing compounds.
- Soaps and detergents.
- Frosting glass.
- Stone and marble polishing.
- Sawing stone with blade or wire.
- Cleaning by tumbling.

Sand for railroad use:

- Sanding rails of steam railroads.
- Sanding rails of electric railroads.

Sand for filtering purposes:

- Municipal water purification.
- Industrial water purification.
- Household water purification.
- Oil refining.

Sand for foundry purposes:

- Molding sand for iron, steel, brass, bronze, aluminum, Dow-metal, etc.
- Core sand.
- Opening and parting sand.
- Finely ground sand for foundry mold wash.

Sand for ceramic uses:

- Potters flint for china and porcelain bodies and for glazes and enamels.
- Setting and packing saggers.
- Sanding brick in setting.
- Sanding molds in common brick making.
- As component in sand-lime brick.
- Sand and clay mixtures for kiln daubing.

Sandstone for refractory purposes:

- Hearths and linings of charcoal furnaces (pioneer days).
- Walls of charcoal furnaces.
- Lining hearths of forges (pioneer days).
- Lining Bessemer converters (ganister used).
- Lining of cupolas.
- Lining of lime kilns (not common).
- Lining of ore-roasting kilns (pioneer days).
- Lining brick kilns (pioneer days).
- Hearths and chimneys of homes.
- Lining baking ovens (pioneer days).
- Sandstone base for kettle in tar making (pioneer days).

¹³Geol. Sur. Ohio, Fourth Series, Bull. 22, pages 20 and 21.

Sand for refractory purposes:

Packing walls of charcoal furnaces (pioneer days).

Pig beds at blast furnaces.

Slag runners at blast furnaces.

Uses of sandstone formations under deep covering:

Accumulation of petroleum.

Accumulation of natural gas.

Storage of natural and artificial gas.

Source for brine.

Source of potable water.

Various uses of conglomerates or pebbles therefrom:

Pebbles for reduction to the metal silicon.

Pebbles for tar roofing.

Pebbles for chicken grit.

Pebbles for greenhouse purposes.

Pebbles for facing concrete blocks.

Pebbles for facing stucco walls.

Pebbles for nitrating beds in sewage disposal plants.

Conglomerate for manufacture of silica brick.

Conglomerate for roads and driveways.

Conglomerate for walks and terraces.

Conglomerates for sand blasting.

Conglomerates for railroad ballast.

Conglomerates for concrete.

Conglomerate stone for decorative effects in walls, chimneys, gardens, etc.

Sand used in building materials:

Mortars.

Plasters.

Cement mixtures.

Asbestos shingles and tiles.

Mastic for walls, joints, etc.

Asphalt paving mixtures.

Composition flooring.

Gypsum plaster combinations.

To keep rolled tar paper and shingles from sticking.

Sandstone for construction purposes:

Mill dams.

Mills and factories.

Mill blocks.

Canal locks and aqueducts.

Bridges.

Bridge and ice piers.

Abutments.

Arches.

Culverts.

Retaining walls.

Riprap.

Breakwater stone.

Railroad ballast.

Road stone.

Paving block.

Rubble stone.

Building stone, facing, sills, lintels, etc.

Foundations.

Underpinnings.

Platforms.

Steps.

Walks and sidewalks.

Flagging.

Curbing.

Burial vaults.

Tombstones.

Mausoleums.

Base of monuments.

Burial lot markers.

Stone fences.

Stone fence posts.

Silica for chemical uses:

Component for cements.

Component of certain slags.

Sodium silicate manufacture.

Silicon carbide (carborundum) manufacture.

Control of clinker in coal.

Silicon tetrachloride for use in screening vessels.

Silica acid, silica gel, for an absorbent.

Silicon tetramethyl, $\text{Si}(\text{CH}_3)_4$ for chemical uses.

Silicontetra ethyl $\text{Si}(\text{C}_2\text{H}_5)_4$ for chemical uses.

Finely ground sand:

Body in paints.

Antioxidants.

Cosmetics and dentifrices.

Filler in rubber.

Wood filler.

Other uses:

Sand for standard cement testing.

Sand for chemical laboratory use.

Sand for sanding roads when icy.

Sand for foundations of pavements.

Sand for filler of fertilizers.

Sand for bedding in stock cars.

Sand for use by blacksmiths in welding iron and steel.

Sand for use in mechanical toys.